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Diurnal and Nocturnal Insect Diversity in Sugar Cane Plantations in Paddy Area in Pagak District, Malang Regency

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Abstract. Paddy sugar cane plantations are a variation of the spatial layout of sugar cane plantations which have the characteristic that the land tends to be more humid. Insects are a part of the ecosystem and they play various ecological roles in it. Pagak District is a sugar cane-producing area with various types of land, one of which is paddy fields. This research aims to determine the diversity of diurnal and nocturnal insects on sugar cane plants in paddy fields in Pagak District, Malang Regency. This research was carried out in February – July 2023 on sugar cane plantations in the paddy fields of Pagak District, Malang Regency. The method used is a direct exploration method on 2 types of traps (yellow traps and light traps). The sampling technique was a purposive random sampling technique with varying times during the day and at night. Diversity index analysis in this study used the Shannon-Wiener formula. The results showed that in the yellow traps, the dominant species was *Bactrocera dorsalis*. Meanwhile, in the light traps, the dominant species is *Scirpophaga nivella*. Furthermore, the results of the analysis of the insect diversity index on sugar cane plants in paddy fields with temporal variations during the day are at a medium diversity level with a value of H' = 1.55. Meanwhile, sugar cane plants in paddy fields with night time variations are at a medium level of diversity with a value of H' = 2.56.

1 Introduction

Insects are animals that have an ecological role in plantation ecosystems, because in plantation ecosystems insects can act as pollinators, predators, decomposers, parasitoids, and so on. Based on their activity, there are diurnal insects which are active during the day and nocturnal insects which are active at night [1]. In plantation ecosystems, both diurnal and nocturnal insects can have positive, negative and neutral ecological relationships [2].

Sugarcane (*Saccharum officinarum*) is a plant that is usually cultivated in the form of plantations. Sugar cane is an annual plantation crop that can live on several types of land with insects as part of its ecosystem. Sugarcane plantations can be created on various types of land because sugarcane plants can live both in the highlands and lowlands. However, the priority land for planting sugar cane is land with little water content [3]. One of the lands used for

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growing sugar cane is paddy fields. Paddy fields land tend to be wetter than ordinary land. Paddy fields used to plant sugarcane need to pay attention to the amount of water so that it does not become excessive and cause the plants to rot and die. Paddy field sugarcane plantations also have insects as part of their ecosystem.

Pagak District, Malang Regency is an area that cultivates sugar cane plants on several types of land, one of which is paddy fields. The sugar cane plant in Pagak District is a type of ratoon cane, Ratoon sugar cane plants are sugar cane plants that come from post-harvest sugar cane shoots. The shoots are cared for until they become sugarcane plants ready for harvest [3].

The paddy fields used for sugar cane plantations in Pagak District are the result of the conversion of paddy plantation land into sugar cane plantation land. This conversion activity will certainly affect the ecosystem composition of the area. One of the ecosystem components that will be affected is insects, both diurnal and nocturnal. This can happen because the presence of insects in an area can be influenced by various factors, one of which is abiotic factors. The presence and density of a type of insect in a place are very dependent on environmental factors, both abiotic environmental factors and biotic environmental factors [4]. This is in line with differences in ecosystem structure that are influenced by abiotic factors such as light intensity, temperature, and humidity [5].

If basic information regarding insect composition in the area concerned is ignored, the worst possibility could be that it could affect plant health and plantation yields. To prevent crop failure or crop damage in paddy-field sugar cane plantations, it is necessary to carry out research regarding insect diversity in paddy-field plantation areas. The research data can be used as reference data to determine the appropriate management system when plantation problems occur, especially those caused by insects. Therefore, this research aims to determine diurnal and nocturnal insect diversity in sugarcane plantations in paddy area in Pagak District, Malang Regency.

2 Material and method

2.1 Study area

This research was carried out in February - July 2023. The observation location was located in a sugar cane plantation in paddy fields in the Pagak District, Malang Regency. The place for insect sample identification was carried out at the Integrated Laboratory and Halal Center of the Islamic University of Malang. The following is a map of insect sampling locations located in sugar cane plantations in paddy fields, Pagak District, Malang Regency, Fig. 1.

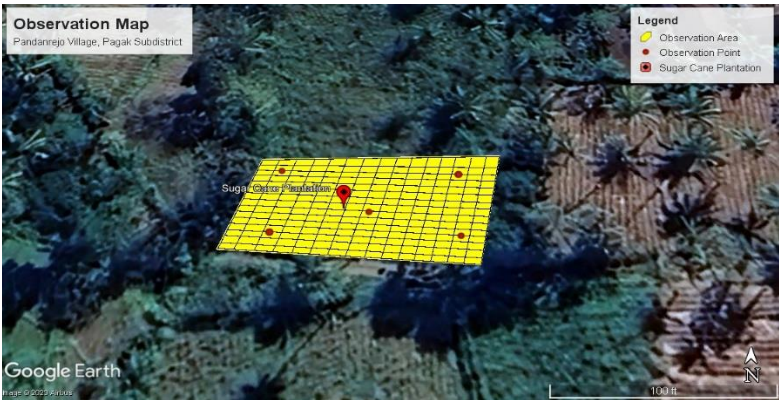

Fig. 1. Observation location

2.2 Data collection

The method applied in this research is an exploration method or direct observation with a sampling technique in the form of purposive random sampling. There are five sampling points determined using a purposive random sampling technique. Observation points are considered by looking at the condition of the plant mound area. The area that is the observation point must be able to accommodate two types of traps at once. Apart from that, to maximize the results of the observations, the researchers determined four observation points based on the cardinal directions (north, south, west, and east) and one observation point the researchers placed in the middle area.

At each point, two types of insect traps are installed, consisting of yellow traps and light traps, which are installed at different time periods. Yellow traps are installed during the daytime period (06.00 AM - 17.00 PM), while light traps are installed during the night time period (17.00 PM - 06.00 AM). So insect data collection was carried out twice, namely in the morning and evening. This division of time aims to group insects based on their activities, namely diurnal insects and nocturnal insects. The intensity of repetition of observations is 3 repetitions with a distance between repetitions of 3 days, to provide time for naturalization at each observation station.

Insects obtained at the research location were then identified in the laboratory with the help of a stereo microscope. Identification is carried out using the results of observations of visible morphological characteristics and adapted to books and journals related to insect identification up to the species level.

Apart from collecting insect data, data was also collected on abiotic factors which have the possibility of influencing insect abundance. The abiotic factors measured are light intensity, air humidity, air temperature, soil pH and soil moisture.

2.3 Data analysis

The insect data obtained was then calculated for the average value (mean) and standard deviation value. The related data was also analysed further using the Shannon-Wiener formula to determine the diversity index and the Pearson correlation formula to determine the correlation of abiotic factors with insect abundance at the observation location. Equation 1 is the Shannon-Wiener formula to determine the insect diversity index [6].

$$H' = -\sum_{i=1}^{s} (pi)\,(ln\;pi) \qquad (1)$$

where,
H' = Shannon-Wiener diversity index
pi = Number of individuals of a species/total number of all species (ni/N)
ni = Number of individual species
s = Total number of individuals

Table 1. Shannon-Wiener criteria

No.	Diversity Index	Information
1	H' < 1,0	Low Diversity Index
2	1.0 ≤ H' 3	Medium Diversity Index
3	H' > 3	High Diversity Index

Meanwhile, to determine the correlation between abiotic factors and insect abundance, the Pearson correlation test was used. Correlation analysis can show the strength and direction of the correlation between two variables. Equation 2 is the Pearson Correlation formula [7]. The level of relationship in Pearson correlation analysis can be found out from the Table 2.

$$r = \frac{n\Sigma XiYi - \Sigma Xi\Sigma Yi}{\sqrt{(nXi^2 - (\Sigma X)^2)(n\Sigma Yi^2 - (\Sigma Y)^2)}} \quad (2)$$

where,
r = Correlation coefficient
∑X = Addition of variables
X∑Y = Summation of Y variables
∑X∑Y = Multiplication of the addition of variables X and Y

Table 2. Level of relationship in Pearson correlation

Coefficient Interval	Relationship Level
0.80 – 1.000	Very strong
0.60 – 0.799	Strong
0.40 – 0.599	Strong enough
0.20 – 0.399	Low
0.00 – 0.199	Very low

3 Result and discussion

3.1 Abundance of diurnal and nocturnal insect species in paddy field sugarcane plantations

The abundance of diurnal and nocturnal insect species in this study was obtained after carrying out insect data collection at the research location according to predetermined methods. Diurnal insects are insects that in research were found during the day on yellow trap traps. The yellow trap is one of the traps that researchers used in this research. The targets of this trap are insects that are interested to the yellow colour and active during the day. Insects like contrasting colours, their eyes detect colours in different ways. For example, the green colour on leaves and insect eyes will appear separate between yellow and blue (green is a combination of yellow and blue). The yellow colour in the insect's eyes indicates that the fruit is ready to eat (ripe). That is the reason why yellow colour can attract most insects to land [8]. There are 10 species of insects found in yellow traps and these insects have the status of diurnal insects. This is concluded on the basis that diurnal insects are insects that are active during the day and yellow traps are traps that researchers install during the daytime period (06.00 AM - 17.00 PM). The following is a table of insect species identification results in yellow traps (Table 3).

Table 3. Insect species data in yellow traps

Order	Family	Species	Repetition			Mean	Standard Deviation
			I	II	III		
Diptera	Tephritidae	*Bactrocera dorsalis*	90	84	97	90	6.51
	Psychodidae	*Clogmia albipunctata*	4	4	5	4	0.58
Heminoptera	Agaonidae	*Blastophaga psenes*	2	5	4	4	1.53
	Diapriidae	*Trichopria anastrephae*	4	7	6	6	1.53
	Eulophidae	*Tetrastichus schoenobii*	3	2	3	3	0.58
	Formicidae	*Anoplolepis gracilipes*	7	8	10	8	1.53
		Tapinoma melanocephalum	12	30	21	21	9.00
		Monomorium hospitum	9	6	4	6	2.52
Homoptera	Cicadidae	*Idiocerus* sp.	5	4	8	6	2.08
Thysanoptera	Sericothripinae	*Neohydatothrips samayunkur*	13	6	11	10	3.61
∑ 4 order	**8**	**10**	**149**	**156**	**169**	**158**	**29.45**

There are 4 orders of insects originating from the orders Diptera, Heminoptera, Homoptera, and Thysanoptera. Amount of insects caught was from the order Diptera family Tephritidae, species *Bactrocera dorsalis* with a mean value of 90. The standard deviation value for the yellow trap was 29.45. Standard deviation can show how varied the data is, higher the standard deviation value, the more varied the data.

Fig. 2. *Bactrocera dorsalis* (Imago)

Bactrocera dorsalis is an animal whose ecological status is a pest for sugar cane plants. Fruit flies (*Bactrocera spp.*) are one of the main pests of horticultural crops in the world. More than a hundred types of horticultural plants are suspected to be the host. In high populations, the intensity of attacks can reach 100% [9].

Next is data on identifying insect species trapped in light traps. A light trap is a light trap intended to catch insects that are active at night (nocturnal). The light trap that the researchers used received a light source from a white flashlight hung on the upper leaves of the sugar cane plant. The following is a table of insect species identification results in light traps (Table 4.

There are nine orders of insects trapped in light traps. In this phase, the insects with the highest abundance came from the Lepidoptera order, the Piralydae family, and the *Scirpophaga nivella* species with a mean value of 7. The standard deviation value for the light trap was 15.10. The standard deviation value of this light trap is lower than for the yellow trap (15.10 < 29.65). That data shows that the insects obtained in yellow traps are more varied than in light traps.

Table 4. Insect species data in light trap

Order	**Family**	**Species**	**Repetition**			**Mean**	**Standard Deviation**
			I	**II**	**III**		
Coleoptera	Anthicidae	*Anthicus tristis schaumi*	3	2	3	3	0.58
		Sapintus hispidulus	2	3	2	2	0.58
	Lampyridae	*Pyractomena angulata*	4	3	4	4	0.58
Diptera	Cecidomyiidae	*Contarina nasturtii*	3	2	3	3	0.58
	Culicidae	*Culicoides dubitus*	3	4	3	3	0.58
	Psychodidae	*Phlebotomus perniciosus*	1	0	1	1	0.58
	Ptychopteridae	*Ptychoptera minuta*	2	2	1	2	0.58
Heminoptera	Formicidae	*Anoplolepis gracilipes*	9	8	5	7	2.08
		Dolichedarus thoracicus	1	0	1	1	0.58
Hemiptera	Delphacidae	*Nilaparvata lugens*	3	5	4	4	1.00
	Psyllidae	*Heteropsylla cubana*	2	1	1	1	0.58
Homoptera	Cicadidae	*Idiocerus sp.*	9	4	6	6	2.52
Isoptera	Rhinotermitidae	*Macrotermes sp.*	3	5	4	4	1.00
Lepidoptera	Pyralidae	*Chilo sacchariphagus*	3	2	2	2	0.58
		Scirpophaga nivella	6	8	6	7	1.15
Psocodea	Psocoptera	*Psyllipsocus ramburii*	1	2	1	1	0.58
Thysanoptera	*Sericothripinae*	*Neohydatothrips samayunkur*	2	0	1	1	1.00
∑ 9 order	**14 family**	**17 species**	**57**	**51**	**48**	**52**	**15.10**

Fig. 3. *Scirpophaga nivella* (Imago)

This insect has ecological status as a pest on sugar cane plants, especially on the tops of leaves and stems of sugar cane plants. The damage caused by sugar cane stems and top borer pests will reduce the volume of sugar cane sap [10].

3.2 Diversity index of diurnal and nocturnal insects in paddy field sugarcane plantations

The diversity of a species in a particular ecosystem. In this research, the researcher used the Shanon-Wiener diversity index analysis, the following analysis data is presented by the researcher in table form:

Table 5. Data level diversity index

Trap	Diversity Index	Level Diversity
Yellow Trap	H' (1.55)	Medium
Light Trap	H' (2,56)	Medium

The results of the analysis of diurnal and nocturnal insect diversity using the Shannon-Wiener diversity index showed that the yellow trap had a diversity index value of 1.55, where this value based on the Shannon-Wiener criteria table was included in the medium diversity level. This also happens with light trap traps, namely getting a medium diversity level but having a different diversity index value. The diversity index value for electric traps is higher than for yellow traps, namely 2.56.

The difference in diversity index values for the two traps can occur due to differences in insect abundance from the species family order level to the individual level. Because if we look at Table 4, it can be known that the value of nocturnal species in the light trap has a value of 17 species. This value is higher than the yellow trap (Table 3) which only got results for 10 species. Differences in ecosystem structure are influenced by abiotic factors such as light intensity, humidity, and temperature [5].

3.3 Influence of abiotic factors on diurnal and nocturnal insect diversity in paddy field sugarcane plantations

Researchers carried out measurements of abiotic factors simultaneously with the process of collecting insect data, so that there were three repetitions of measurement results which the researchers tabulated in the Table 6.

Table 6. Measurement of abiotic factors

Repetition	Time	Air Temperature (°C)	Air Humidity (%)	Light Intensity (lux)	Soil pH	Soil Moisture (%)
I	05.00 AM	20	87	200	7	8
	17.00 PM	23	83	500	8	8
II	05.00 AM	22	84	200	7	6
	17.00 PM	22.8	88	200	7	9
III	05.00 AM	23.2	89	200	8	7
	17.00 PM	25	80	200	8	6

The results of measuring these abiotic factors were then processed using Pearson correlation to determine the correlation of abiotic factors with the abundance of diurnal and nocturnal insects in sugarcane plantations in paddy fields. The results of Pearson correlation analysis are presented in Table 7 below:

Table 7. Correlation of daytime period abiotic factors on insect abundance

Correlation Components	Air Temperature (°C)	Air Humidity (%)	Light Intensity (lux)	Soil pH	Soil Moisture (%)
Pearson Correlation	0.948*	0.894*	0.924*	0.811	0.624
Sig. (2-tailed)	0.014	0.041	0.025	0.096	0.261

(*): there is a correlation with insect abundance

Based on table 7 about the results of the correlation analysis of abiotic factors with the diurnal abundance of individual insects, it is known that the abiotic factors which have an influence on the abundance of individual insects are air temperature, air humidity and light intensity. That means that these three abiotic factors significantly influence the abundance of individual insects. Furthermore, based on the correlation value interpretation in Table 7, researchers can find that air temperature, air humidity, and light intensity have a strong correlation in this phase. The direction of the correlation is positive (directly proportional). That means that the value of individual insect abundance increases can only occur when the values of air temperature, air humidity and light intensity also increase.

Table 8. Correlation of night time period abiotic factors on insect abundance

Correlation Components	Air Temperature (°C)	Air Humidity (%)	Light Intensity (lux)	Soil pH	Soil Moisture (%)
Pearson Correlation	1	0.963**	0.878*	0.875	-0.455
Sig. (2-tailed)		0.009	0.050	0.052	0.441

(*) : there is a correlation with insect abundance

Based on Table 8, researchers can find out that the abiotic factors that influence the abundance of individual nocturnal insects consist of two abiotic factors, namely air humidity and light intensity. The abiotic factor that has strong influence in this phase is air humidity it has a correlation value of 0.963 with a significance value of 0.009. The correlation between these two factors is included in the strong correlation category with a positive (directly proportional) correlation direction. It means that an increase in the reported value of individual insects can only occur if the value of air humidity and light intensity also increases.

4 Conclusion

Based on the research that has been carried out, it can be concluded that the dominant diurnal insect type is *Bractocera dorsalis* (Diptera: Tephritidae) with a mean value of 90. Meanwhile, the dominant nocturnal insect type is *Scirpophaga nivella* (Lepidoptera: Pyralidae) with a mean value of 7. The standard deviation value in the light trap is lower than the yellow trap (15.10 < 29.65), which means that the insects in the yellow trap are more varied than in the light trap. Analysis of the insect diversity index on sugar cane plants in paddy fields using yellow traps and light traps was at medium level with a value of H' = 1.55 for yellow traps and H' = 2.56 for light traps. Abiotic factors during the day and night data collection period had a significant influence on insect diversity at the research location with a Sig. value < 0.05.

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